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Research Article

Trends in Malaysian Adolescents' Mathematics Performance Across Two Decades: What Factors Matter?

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The relationship between individual and school factors plays a crucial role in shaping adolescents' mathematics achievement. Individual factors, such as a student's motivation and educational expectation, directly influence their engagement and persistence in mathematical learning. Concurrently, school factors, including teacher quality and the availability of resources, create an environment that either fosters or hinders students' academic success in mathematics. Together, these factors underscore the need for a holistic approach to education that recognizes the interconnectedness of personal and institutional influences on student performance. Thus, this study investigates which individual and school factors have been associated with adolescents' mathematics achievement over the last two decades. We examined six-wave data from Malaysia in the Trends in International Mathematics and Science Study (TIMSS). A multilevel modeling technique was employed for data composed of 5557, 5314, 4466, 5733, 9726, and 7065 eighth-grade students participating in 1999, 2003, 2007, 2011, 2015, and 2019, respectively. The results showed that 65.17%, 57.44%, 65.89%, 73.00%, 43.16%, and 61.69% of the total variance in mathematics achievement was due to school differences in these years. The findings also indicated that students with higher mathematics motivational beliefs scored higher. Students who more frequently spoke the language of the test at home achieved lower scores in four waves of TIMSS; however, this trend changed in 2015 and 2019. Student educational aspiration emerged as a positive predictor of mathematics achievement in the last two assessments of TIMSS. Home educational resources and book ownership also significantly correlated with mathematics achievement. At the school level, teacher gender was negatively associated with achievement in all TIMSS waves except 2019. Students whom female teachers taught outperformed those whom male teachers taught. The longitudinal study of Malaysian students' mathematics performance reveals critical insights for educational stakeholders. The findings indicate that 43.16% to 73.00% of the variance in mathematical achievement is linked to school differences, underscoring the importance of equitable resource distribution. Moreover, students' motivational beliefs significantly influence their mathematics scores, suggesting a need for interventions that foster positive attitudes. The evolving correlation between home language proficiency and achievement emphasizes the necessity of integrating language support into educational strategies. Additionally, promoting educational aspirations is vital for enhancing performance, while the role of gender dynamics in teacher effectiveness warrants further exploration.

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1. Introduction

The Malaysian education system has focused on math and science, aiming to become a STEM-driven economy by 2025. As a result, developing a high-quality science and mathematics workforce has become critical in fostering students' interest, attitudes, and knowledge of STEM-related careers[1]. However, students struggle with fundamental math skills and rely too heavily on calculators[2]. International assessments show a decline in math performance over time[3].

In 1999, Malaysia joined TIMSS, an organization that assesses students' proficiency in math and science, identifies factors contributing to success in these subjects, monitors achievement over time, and promotes cross-country learning among policymakers[4]. TIMSS conducts assessments every four years, allowing countries to monitor student performance and teaching factors[3]. This study aims to examine trends in math performance among Malaysian students from 1999 to 2019 and identify key factors influencing these patterns using TIMSS data.

According to Mullis et al.[3], Malaysian students' average math scores have been declining steadily. In 1999, the average score was 519, which decreased to 508 in 2003, 474 in 2007, and 440 in 2011. The trend continued with scores of 465 in 2015 and 461 in 2019. The TIMSS assessment categorizes students' performance into four levels: advanced (625), high (550), intermediate (475), and low (400). In 1999, 10% of Malaysian students achieved the advanced level, but this percentage dropped to 6% in 2003, 2% in 2007, 2% in 2011, 3% in 2015, and 4% in 2019. Similarly, the proportion of students reaching the high level also decreased over the years. In 1999, 36% of Malaysian students reached the high level, but this figure declined to 30% in 2003, 18% in 2007, 12% in 2011, 18% in 2015, and 17% in 2019[3].

In Malaysia, the educational system is centralized and provides 11 years of free education, including primary and secondary school. Primary school is compulsory for children aged 6-11 and lasts for six years. After primary school, students take the primary school achievement test (UPSR). Secondary school is divided into lower secondary (Forms 1 and 2) and upper secondary (Forms 3 to 5), lasting for five years. At the end of secondary school, all students must take the Malaysian Certificate of Education or Sijil Pelajaran Malaysia (SPM). The results of the primary school achievement test are used as a criterion for admission into specific secondary schools, but there is no segregation based on abilities[5].

Malaysia has a diverse population with three major ethnic groups: Malay, Chinese, and Indian. The official language is Bahasa Malaysia (BM), but many Malaysians are also proficient in English. In 2002, the government introduced teaching math and science in English to improve students' skills, but in 2009, they decided to switch back to BM as the language of instruction by 2012[5]. This change also affected students' math achievement[6].

Mathematics performance among Malaysian eighth-grade students has experienced a notable and persistent decline from 1999 to 2019. This study intends to investigate the trends evident during this period, aiming to elucidate the factors that have significantly influenced these changes, as derived from the TIMSS data. By pinpointing these critical factors, this research endeavors to provide insight into the underlying causes of this decline in mathematics achievement, thereby contributing to the discourse on educational improvement and policy formulation in Malaysia.

1.1. School effectiveness model for student mathematics achievement

The "Coleman Report" marked the start of school effectiveness research[7]. It revealed that schools had minimal influence on students' academic performance once family background factors were considered. This sparked debate among scholars, leading to

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educational reforms and advancements in research methods. Numerous studies have since been conducted using large-scale assessments and sophisticated methodologies to investigate the impact of schools on student achievement (e.g., [8][9][10]). Researchers have proposed solutions in educational inputs and processes[11], resulting in the development of various models in school effectiveness research (e.g., [12][13]).

Some of these models (e.g., [13]) are based on the economic theory known as the education production function[14] (EPF).

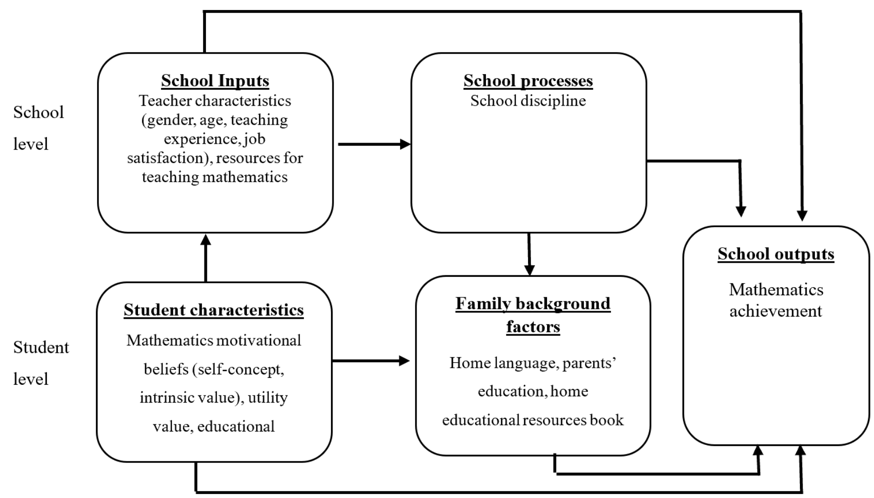

Fig. 1. *A multilevel conceptual model of school effectiveness*

In 2006, Hanushek identified three components of the educational school system: inputs, processes, and outputs. However, according to Kolawole in 2021[15], school outcomes are determined by inputs and processes. Nugba et al.[16] further categorized factors that affect school outcomes into school inputs, practices, and processes. School inputs refer to characteristics that impact school outcomes, such as students' abilities, attitudes, home environment, and resources. Examples include teacher qualifications, student-teacher ratio, and expenditure per student. Processes encompass teaching quality, style, time spent on subjects, student composition, school organization, disciplinary climate, and achievement pressure.

Teacher quality is crucial for student achievement, as shown by a cross-national study[17]. Measurable indicators like age, experience, and job satisfaction determine teacher quality. Research indicates that older teachers are more effective, with those aged 31-40, 41-50, and 50+ scoring higher than those aged 21-30[18]. However, another study suggests that age does not significantly affect academic performance[19].

Many professions value employees' experience, including education, where teacher experience is important[20]. Research shows a strong link between teacher experience and higher student achievement, as well as improved test scores and behavior[21].

Studies show no correlation between teaching experience and academic performance in math and science[22][23]. Contrary to expectations, experienced teachers do not necessarily have a greater impact on student achievement. The most significant growth in teacher effectiveness occurs in the first three years of their career[17].

Teachers' gender can impact students' academic achievement through role modeling, stereotype threats, and biases[24]. Female teachers may have a greater impact due to

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their higher levels of math anxiety and different approaches to teaching[25]. Gender biases can also affect teacher-student interactions[26]. While some studies show a positive association between female teachers and student achievement[27], others find no correlation[28].

1.2. Effects of individual-level factors on student mathematics achievement

Scholars agree that schools impact students' academic performance[29][13]. However, there is ongoing debate about the specific factors at the student and school levels that contribute to these differences. Research shows that student characteristics, such as beliefs, family background, and language spoken at home, are linked to academic achievement[13]. Students' self-perception, intrinsic value, and perceived usefulness of mathematics also influence their learning[30].

Expectancy and values are two critical factors impacting student mathematics achievement. Expectancy refers to an individual's anticipation of a certain outcome based on their experiences and knowledge, while values relate to the reasons for doing a task. Values can be categorized into four types: attainment, intrinsic, utility, and cost[31]. Academic performance has been extensively studied in relation to students' educational expectations[32][33]. A significant finding was that having high educational expectations for future studies was identified as a predictor of academic performance[34]. Math is a key subject in schools, valued in specific fields like commerce, technology, and science[35]. Research shows a positive link between valuing math and academic success[36][37]. In Malaysia, eighth-grade students show interest in learning math but don't see its practical benefits. They recognize its importance and real-world applications but view it as unnecessary in the school curriculum[38]. In the PISA 2012 evaluation, Malaysian students showed higher instrumental motivation and mathematical interest compared to the OECD average, but also had higher mathematics anxiety[39]. Additionally, the intrinsic value of students was linked to the complexity and quantity of math problems, while math anxiety had a negative effect on problem complexity[40]. Girls have lower anxiety towards math, but this can lead to a negative perception of the subject[41]. Boys pursue math for practicality and career prospects, while girls enjoy it more[42].

Self-concept is crucial for students' academic performance, including in mathematics[43][30][44][45]. It refers to individuals' beliefs about their abilities and encompasses various dimensions[46]. Studies in Malaysia have shown the significant influence of self-concept on eighth-grade students' academic achievement[27]. Factors such as self-confidence, aspirations, school safety perception, and time spent on math homework also correlate with math achievement[27]. Boys tend to have higher math self-concepts than girls[47].

Intrinsic value, rooted in mathematics, significantly impacts students' academic achievement and self-perception. It evolves as students progress through education and is a key objective in math education worldwide[3]. Early development of intrinsic value predicts future success in math and related fields[43][48][44]. Extensive research consistently shows its strong association with math success (e.g., [49][50][51][52]). Intrinsic value is also influenced by students' perception of their parents' attitudes, with middle-class students exhibiting more positive intrinsic value[52]. Factors such as the home environment[53][54][55], teachers' attitudes[56][35], classroom instruction[57], parental aspirations[58], and parents' self-efficacy in math can influence intrinsic value[59].

Research consistently shows that students who have greater access to educational resources at home, such as books and higher socioeconomic status, tend to perform better academically, particularly in mathematics (e.g., [3][60][61][6]). A study conducted in

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Malaysia found that home educational resources were the most influential predictor of mathematics achievement among eighth-grade students. Similarly, research in Malaysia has shown that students from homes with more educational resources achieve higher scores in both mathematics and science[27]. Additionally, students tend to perform better when their parents have higher levels of education and when they have access to additional resources like study desks, computers, and books at home[27].

Numerous studies have found a correlation between home language and academic achievement, particularly in mathematics. Students who speak the test language more frequently at home tend to perform better[62][63][3][64]. However, a study on Malaysian students showed that speaking Bahasa Malaysia at home did not lead to higher science scores[65]. This contradicts previous research (e.g., [66][67]). Interestingly, Malaysian students who didn't speak Bahasa Malaysia at home performed better in mathematics. Those who spoke it more frequently scored 13 points lower in TIMSS 2007[60].

2. Research Questions

The observed decline in Malaysian eighth-grade students' performance in TIMSS highlights a critical area requiring urgent academic inquiry. By conducting a study that examines the intricate relationships between teacher quality and student-related factors, we can gain valuable insights into the underlying causes of this trend. Such findings will be instrumental in informing educators, policymakers, and stakeholders, ultimately contributing to the enhancement of educational strategies and the improvement of students' mathematical achievement in Malaysia. Therefore, the present study was designed to investigate the following questions:

1. How are student-level factors correlated with Malaysian eighth-graders' mathematics achievement?
2. How are the school-level factors correlated with Malaysian eighth-graders' mathematics achievement?
3. What is the trend of the relations of these factors with the mathematics achievement of Malaysian eighth-graders across the TIMSS assessments?

3. Methods

3.1. Samples

The data for this study were obtained from the TIMSS assessments. A total of 5557, 5314, 4466, 5733, 9726, and 7065 nationally representative eighth-grade students from 150, 150, 150, 180, 207, and 177 secondary schools from Malaysia participated in TIMSS 1999, 2003, 2007, 2011, 2015, and 2019, respectively. TIMSS consistently used a two-stage stratified cluster sampling design. Schools were randomly sampled after considering their size, and then one intact classroom within each selected school was selected.

3.2. Measures

Predicted factor (mathematics achievement): The five plausible values were averaged and used as the predicted factor. TIMSS used a test to measure students' mathematics achievement. Many items (e.g., 215 items in TIMSS 2007) were used to extend the coverage of the mathematics content and measure the trends across the TIMSS assessments[68]. Indeed, implementing all the items for individual students was impossible. Thus, a matrix-sampling design was used to assemble the items into different booklets, and each student completed only one booklet consisting of a small sample of the items. The plausible values estimate how a student might have performed if it had been administered to the entire set of items. The plausible values for individual students were estimated based on their answers to a subtest of the mathematics items. The plausible values for any given scale are the best available measures of students'

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achievement, and they should be used as the outcome variable in any study of student achievement[69].

Predictors at the student level include eight factors. (1) *Self-concept,* based on students' responses to (a) I usually do well in math, (b) I learn things quickly in math, (c) math is not one of my strengths, and (d) math is more difficult for me on a 4-point Likert scale: 4= agree a lot; 3= agree a little; 2= disagree a little; 1= disagree a lot. The last two statements were reverse coded. High: students who agreed a little or a lot on average with all four statements; Low: students who disagreed a little or a lot, on average; Medium: includes all other response combinations. (2) *Intrinsic utility*, based on students' responses to (a) I enjoy learning math, (b) I like math, and (c) math is boring. The scaling is similar to that of self-concept. The last statement is reverse coded. High: students who agreed a little or a lot on average with all three statements; Low: students who disagreed a little or a lot, on average; Medium: includes all other response combinations. (3) *Utility value*, based on students' responses to (a) learning math will help me in my daily life, (b) I need math to learn other school subjects, (c) I need to do well in math to get into the university, (c) I need to do well in math to get the job I want, and (d) I would like a job to involve math. The scaling is similar to that of self-concept and intrinsic utility. High: students who agreed a little or a lot on average with all four statements; Low: students who disagreed a little or a lot, on average; Medium: includes all other response combinations. (4) *Educational aspiration*, based on students' responses to "How far in school do you expect to go?", 1=Low, upper or post-secondary; 2= Medium, diploma or first degree; 3= High, beyond first degree. (5) *Home language*, based on students' responses to "How often do you speak the language of the test at home?", 1= always; 2= almost always; 3= sometimes; 4= never. These codes are recoded to (0 sometimes and never; 1 always and almost always). (6) *Parents' education*, based on students' responses to "What is the highest level of education completed by your mother (or stepmother or female guardian) and father (or stepfather or male guardian)?", 1= Low, less than or complete lower secondary school; 2 = Medium, complete lower or upper secondary school; 3= High, university degree. (7) *Home educational resources*, based on students' responses to the four statements on a two-point scale: (a) having a calculator, (b) having a computer, (c) having a study desk, and (having a dictionary). TIMSS coding was: 1= Yes; 2= No. Responses were classified into three categories: 1= Low if responded "No" to all or three of the four statements; 2= Medium, all other response combinations; 3= High if responded "Yes" to at least three or all of the four statements. (8) *Book ownership*, based on students' responses to "How many books are there in your home excluding magazines, newspapers, or your school books?", 1 Low, none or enough to fill one shelf (11-25 books); 2 Medium, enough books to fill one bookcase (26-100 books); 3 High, enough books to fill two bookcases (101-200 books); or more.

Predictors at the school level include six factors. (1) Teacher teaching experience as stated by teachers in number, (2) teacher gender (male=1, female=0), (3) teacher age, as stated by teachers in number, (4) school discipline, based on the principal's school response to (a) arriving late at school, (b) absenteeism, (c) skipping class, (d) cheating, (e) profanity, (f) vandalism, (g) theft, (h) physical injury to other students, and (i) physical injury to teacher or staff, on a 4-point Likert scale: 1= not a problem; 2= minor problem; 3= moderate problem; and 4= serious problem. Cut scores divide the scale into three categories. Low: Students in schools with hardly any problems had a maximum score of 13, corresponding to their principals reporting that five of the nine discipline issues are "not a problem," and the other four are "minor problems." Minor: Students in schools with minor discipline issues scored between 14 and 23, corresponding to their principals reporting that five of the nine issues are a "moderate problem" and the other four are "minor problems." High: All other students attended schools with "moderate problems." (5) Teaching affected by resource shortages for mathematics instruction, based on the principal's school response to (a) computers for mathematics instruction, (b) computer software for mathematics instruction, (c) calculators for mathematics instruction, (d) library materials relevant to mathematics instruction, and (e) audio-visual resources for mathematics instruction, on a 4-point Likert scale: 1= not at all; 2= a little; 3= some; and 4= a lot. Cut scores divide the scale into three categories. Low: Students in schools where instruction was "not affected" by resource shortages had a maximum score of 7, corresponding to their principals reporting that shortages affected instruction "not at all" for three of the five resources and "a little" for the other two. Moderate: Students who attended schools where instruction was "somewhat affected" by resource shortages had scores between 8 and 13. High: All other students attended schools where instruction was "affected a lot" by resource shortages. (6) Teacher job satisfaction, based on the school principal's response to (a) I am content with my profession as a teacher, (b) I find my work full of meaning and purpose, (c) I am enthusiastic about my job, (d) My work inspires me, and (e) I am proud of the work I do; on a 4-point Likert scale: 1= very often; 2= often; 3= sometimes; and 4= never or almost never. Low: Students with very satisfied teachers had a maximum score of seven, corresponding to their teachers responding "very often" to three of the five statements and "often" to the other two. Students with somewhat satisfied teachers scored between 8 and 13, responding "sometimes" to three of the five statements and "often" to the other two—all other students with less than satisfied teachers.

3.3. Data analysis

Two-level hierarchical linear modeling (HLM) was applied in this study. The TIMSS data are nested or multilevel structured data. Students are nested within the classroom, and the classroom is nested within schools. Thus, it makes three-level structured data: students as level-1, classroom as level-2, and school as level-3. However, TIMSS data are three levels in nature, as with most other participating countries; in Malaysia, only one intact classroom was sampled per school. There was no possibility of disentangling the effect of classroom and school; thus, classroom and school combined to make the school level. The data were analyzed using HLM6.07[70].

The Full Maximum Likelihood (FML) was used to estimate the parameters[71][72]. The grand mean centering was used as a centering approach at the student and school levels (for details, please refer to [73][71][74][72]). The TIMSS sampling design was multistage stratified cluster sampling. In these designs, individuals are nested within clusters, and clusters are nested within strata. Thus, the probability of the selected sample units is not equal. We used sampling weights to avoid bias in parameter estimation, as experts suggested[75][76]. The house weight (HOUWGT) at the student level and the school weight (SCHWGT) at the school level[76] were used as weighting samples in this study; however, as the weighting method at the school level changed in TIMSS 2019, the school weight factor (WGTFAC1) was used instead of SCHWGT.

3.4. The Estimated Models

A set of models was estimated: (a) the Null Model, in which no individual- or group-level predictors exist. This Model is also known as a one-way ANOVA[77]. We used this Model to calculate the intraclass correlation coefficient (ICC), a measure of how much of the variance in mathematics achievement was accounted for by the "cluster effect." (b) Model-1: In this Model, all the student-level factors were included as fixed effects. The fixed effects refer to the effects of student-level factors that are assumed to have the same effect on achievement across all schools. (c) Model-2: In this Model, all the school-level factors entered into the Model together. (d) Model-3: In this Model, all the student-level factors (averaged) are aggregated and added to the school-level model after controlling for all the school-level factors, the so-called compositional or contextual effect. (e) the Full Model: In this Model, all the student- and school-level factors are added into the Model simultaneously.

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4. Results

4.1. The Null Model

The proportion of variance in mathematics achievement due to school-level differences was computed by $\rho = \tau_{00} / (\tau_{00} + \sigma^2)$, where ρ is the Intra-class Correlation (ICC), σ^2 is the student-level variance, and τ_{00} is the school-level variance. In TIMSS 1999, for example, σ^2 = 2104.71 and τ_{00} = 3938.54. Therefore, the ICC (ρ) = 3938.54/ (3938.54 + 2104.71) = 0.6517. That is, 65.17% of the total variance in the mathematics achievement of Malaysian eighth-grade students was due to school-level differences. The proportion was 57.44%, 65.89%, 73.00%, 43.16%, and 61.69% in 2003, 2007, 2011, 2011, and 2019, respectively.

4.2. Model 1

Model 1 was estimated using all the student-level factors. These factors were the same across all the TIMSS assessments, except for TIMSS 1999, where the data for mathematics self-concept were unavailable. The proportion reduction in the student-level variance was computed by (σ^2 the Null Model -σ^2 Model- 1)/σ^2 the Null Model. Model 1 accounted for 9.39%, 25.46%, 18.94%, 18.14%, 21.33%, and 17.15% of the student-level variance in mathematics achievement in 1999, 2003, 2007, 2011, 2015, and 2019, respectively. Theoretically, the student-level predictors also explain the school-level variance but not vice versa. The regression coefficients of the parameters in Model-1 are presented in Table 1.

β	TIMSS 1999	TIMSS 2003	TIMSS 2007	TIMSS 2011	TIMSS 2015	TIMSS 2019
1	No data available	16.11** (0.70)	13.07** (0.92)	8.76** (0.75)	18.07** (0.92)	11.69** (0.82)
2	12.70** (0.92)	16.71** (0.71)	6.56** (1.15)	14.67** (0.69)	16.65** (1.11)	10.76** (1.00)
3	0.33 (0.63)	1.18 (0.76)	0.44 (1.16)	2.96** (0.77)	4.41** (0.91)	2.05* (0.89)
4	4.47** (0.90)	0.82 (0.79)	0.10 (1.14)	0.62 (0.70)	17.46** (1.97)	13.26** (1.63)
5	-14.80** (3.00)	-20.87** (2.89)	-13.20** (2.58)	-24.62** (2.57)	18.93** (2.52)	10.21** (1.82)
6	3.03** (0.86)	2.42 (1.35)	1.07 (1.19)	0.48 (0.76)	4.88** (1.76)	2.64* (0.87)
7	2.02 (2.12)	2.50 (2.20)	15.42 **(2.88)	6.68**(1.06)	0.52 (1.77)	4.62* (1.28)
8	7.83* (3.01)	2.20 (1.39)	5.97 **(1.43)	2.19*(1.12)	5.87** (1.98)	9.94** (1.83)

Table 1. *Student-level parameters regression coefficients in Model-1*

(1) Self-concept, (2) Intrinsic value, (3) Utility value, (4) Educational aspiration, (5) Home language, (6) Parent's education, (7) Home educational resources, (8) Book ownership
The values within the brackets are standard errors. (*) *p <.05 and* (**) *p <.001*

Self-concept was one of the strongest predictors of mathematics achievement in all the TIMSS cycles. Intrinsic value also produced significant links with achievement in all the assessments. Utility value was significantly related to mathematics achievement in the last three waves of TIMSS. Educational aspiration produced a significant relation with mathematics achievement only in 1999, 2015, and 2019. The relationship between the

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language spoken at home and mathematics achievement was negative in TIMSS from 1999 to 2011. After controlling for the other student-level factors, students who spoke Bahasa Malaysia more at home achieved lower scores than those who did so less frequently. However, the relation turned positive in the 2015 and 2019 assessments; that is, students who more frequently spoke Bahasa Malaysia at home achieved higher scores than those who did so less frequently. Parents' level of education was significantly correlated with achievement in the years 1999, 2015, and 2019. Home educational resources were significantly correlated with mathematics achievement in 2007, 2011, and 2019, while book ownership produced significant links with mathematics achievement in all years except 2003.

4.3. Model 2

All the school-level factors were added to Model 2. These factors are the same across all the TIMSS assessments. However, in TIMSS 2015 and 2019, mathematics teachers' job satisfaction was also included, but the data for these two factors were unavailable in the previous assessments. The variance explained by Model 2 was computed by (t00 the Null Model - t00 Model- 2)/ t00 the Null Model. Model-2 contributed 6.52%, 16.66%, 0%, 10.5%, 0.58%, and 6.26% of the school-level variance in 1999, 2003, 2007, 2011, 2015, and 2019, respectively. The regression coefficients of the parameters in Model 2 are presented in Table 2.

β	TIMSS 1999	TIMSS 2003	TIMSS 2007	TIMSS 2011	TIMSS 2015	TIMSS 2019
1	0.83 (2.85)	3.83 (4.91)	2.16 (6.55)	4.20 (6.55)	-3.76 (7.10)	-21.89* (8.74)
2	-34.99* (13.13)	-37.10 **(9.39)	12.14 (13.22)	-39.35* (15.55)	-7.79 (11.73)	-40.02* (17.64)
3	4.58 (7.60)	−6.78 (9.29)	1.00 (9.37)	0.24 (8.16)	4.65 (9.56)	40.92* (18.00)
4	2.92 (8.68)	-12.31 (7.11)	-2.56 (12.83)	-36.34* (11.90)	52.21 (28.51)	14.700 (12.48)
5	−8.57 (9.04)	-23.92** (5.59)	-3.91 (8.76)	-16.38 (10.01)	-10.02 (8.51)	23.32 (13.71)
6	No data available	No data available	No data available	No data available	−0.65 (8.54)	(11.95)

Table 2. *School-level parameters regression coefficients in Model- 2*

(1) Teacher teaching experience, (2) Teacher gender, (3), Teacher age (4) School discipline, (5) Math teaching affected by resources shortage, (6) Teacher job satisfaction.
The values within the brackets are standard errors. (*) *p <.05 and* (**) *p <.001*

Teacher teaching experience was significantly correlated with mathematics achievement in 2019, and the correlation was negative. Students taught by teachers with more years of teaching scored lower than others. Teachers' gender was significantly correlated with achievement in 1999, 2003, 2011, and 2019. The correlation was negative, indicating that after controlling for the other school-level factors in the model, students whom female teachers taught achieved higher scores than those whom male teachers taught. The relationship between school discipline and mathematics resource shortages, as reported by school principals, with mathematics achievement was negative. Students who attended schools having discipline problems and where resources for mathematics instruction were a problem achieved lower scores than those who attended other schools. However, the relation between school discipline and mathematics achievement was significant only in TIMSS 2011 and 2003, respectively.

4.4. Model 3

In Model 3, after controlling for all the school-level factors, all the student-level factors were aggregated (averaged) and added to Model- 3. The variance explained by Model 3 was computed using (τ_{00} Model 2 - τ_{00} Model 3)/τ_{00} Model 2. Model 3 accounted for 13.64%, 11.09%, 75.97%, 12.07%, 35.20%, and 29.72% of the school-level variance in mathematics achievement in TIMSS 1999, 2003, 2007, 2011, 2015, and 2019, respectively. The regression coefficients of the parameters in Model 3 are presented in Table 3.

β	TIMSS 1999	TIMSS 2003	TIMSS 2007	TIMSS 2011	TIMSS 2015	TIMSS 2019
1	No data available	48.25** (7.00)	45.85* (13.00)	0.25 (5.21)	3.05 (3.55)	67.54** (14.93)
2	6.92 (6.07)	20.82* (8.07)	27.64* (11.07)	2.35 (6.42)	0.93 (3.74)	1.77 (12.43)
3	6.13 (5.57)	36.87* (10.27)	22.65* (9.54)	4.32 (7.40)	2.52 (4.31)	0.90 (10.84)
4	24.82 (17.61)	3.79 (8.77)	4.44 (9.44)	5.89 (5.75)	9.10 (5.20)	117.50** (14.73)
5	54.69* (23.77)	-60.26** (9.50)	-24.31 (12.39)	-3.06 (12.70)	6.84 (10.02)	33.45 (17.55)
6	9.69 (27.18)	35.21* (12.26)	34.81* (10.87)	0.52 (6.43)	7.49 (4.02)	4.84 (7.63)
7	42.92 (42.66)	98.17** (25.78)	145.14** (23.50)	3.47 (8.10)	10.74 (7.27)	20.73 (24.66)
8	41.96* (20.44)	33.88 (21.41)	80.88** (19.10)	8.06 (9.33)	15.76 (8.94)	20.73 (24.66)

Table 3. *The compositional factors parameters regression coefficients in Model-3*

(1) Mean of Self-concept, (2) Mean of Intrinsic value, (3) Mean of Utility value, (4) Mean of educational aspiration, (5) Mean of home language, (6) Mean of parent's education, (7) Mean of home educational resources, (8) Mean of book ownership.
The values within the brackets are standard errors. (*) *p <.05 and* (**) *p <.001*

Mean of self-concept in 2003, 2007, and 2019, both the mean of intrinsic value and mathematics utility value in 2003 and 2007, the mean of educational aspiration in 2019, the mean of the home language in 1999 and 2003, both means of parent's education and mean of home educational resources in 2003 and 2007, and mean of book ownership in 1999 and 2007 produced significant links with mathematics achievement.

4.5. The Full Model

In the Full Model, all the student- and school-level factors were added into the model simultaneously to examine the relations of the student-level factors with mathematics achievement while the school-level factors were controlled, and vice versa. The variance in mathematics achievement explained by the Full Model was computed using (σ^2 of the Null Model -σ^2 of the Full Model) / σ^2 of the Null Model for the student level and (τ_{00} of the Null Model - τ_{00} of the Full Model) / τ_{00} of the Null Model for the school level. The Full Model explained 9.39%, 25.46%, 18.94%, 18.14%, 21.34%, and 17.15% of the student-level variance, and 15.11%, 35.88%, 17.31%, 21.30%, 35.57%, and 34.12% of the school-level variance in 1999, 2003, 2007, 2011, 2015, and 2019, respectively. The regression coefficients of the parameters in the Full Model are presented in Table 4.

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β	TIMSS 1999	TIMSS 2003	TIMSS 2007	TIMSS 2011	TIMSS 2015	TIMSS 2019
1	No data available	16.08 ** (0.70)	13.08** (0.92)	8.75** (0.75)	18.05** (0.91)	11.68** (0.83)
2	12.70** (0.92)	16.72 **(0.71)	6.56** (1.15)	14.68** (0.69)	16.64** (1.11)	10.76** (1.00)
3	0.34 (0.63)	1.20 (0.76)	0.42 (1.16)	2.95 (0.77)	4.43** (0.91)	2.06* (0.88)
4	4.46** (0.80)	0.85 (0.79)	0.10 (1.14)	0.62 (0.70)	17.45** (1.96)	13.23** (1.63)
5	-14.79** (3.00)	-20.90** (2.88)	-13.21** (2.57)	-24.64** (2.57)	18.91** (2.52)	10.20** (1.82)
6	3.01** (0.86)	2.40 (1.35)	1.07 (1.19)	0.47 (0.76)	4.88** (0.96)	2.64* (0.87)
7	1.96 (2.11)	2.47 (2.19)	15.41** (2.88)	6.67** (1.06)	-0.54 (1.77)	4.62* (1.28)
8	7.84* (3.01)	2.19 (1.40)	5.96** (1.40)	2.20 (1.13)	5.84* (1.99)	9.93** (1.84)
9	0.13 (3.27)	3.04 (4.39)	2.79 (5.96)	2.02 (6.25)	-3.04 (5.72)	-17.38* (7.22)
10	-33.56* (12.65)	-32.17** (8.24)	9.78 (12.14)	-38.49* (14.15)	-3.13 (9.65)	32.78* (14.56)
11	9.78 (7.91)	-6.75 (8.18)	0.23 (8.55)	2.77 (7.92)	4.76 (7.69)	33.24* (15.37)
12	3.17 (8.21)	-10.99 (6.50)	-4.32 (11.56)	-34.90* (11.27)	43.37* (18.37)	12.58 (10.68)
13	-8.23 (8.75)	-20.22 **(4.83)	-2.88 (7.90)	-16.64 (9.45)	-8.70 (7.43)	16.89 (11.71)
14	No data available	No data available	No data available	No data available	0.88 (7.01)	16.66 (9.97)

Table 4. *Parameters regression coefficients in the Full Model*

Self-concept, (2) Intrinsic value, (3) Utility value, (4) Educational aspiration, (5) Home language, (6) Parent's education, (7) Home educational resources, (8) Book ownership, (9) Teacher teaching experience, (10) Teacher gender, (11), Teacher age (12) School discipline, (13) Math teaching affected by resources shortage, (14) Teacher job satisfaction. The values within the brackets are standard errors. (*) *p <.05 and* (**) *p <.001.*

After controlling for the school-level factors, mathematics self-concept and intrinsic value produced significant links with mathematics achievement in all years. Utility value was significantly correlated with mathematics achievement in the last two waves. The relationship between educational aspiration and mathematics achievement was significant in 1999, 2015, and 2015. The relationship between the language spoken at home and mathematics achievement in the Full Model was negative in TIMSS from 1999 to 2011. However, the relation turned positive in TIMSS 2015 and 2019. Parent's level of education was significantly associated with mathematics achievement in 1999, 2015, and 2019. Home educational resources were significantly correlated with mathematics achievement in 2007, 2011, and 2019. Book ownership produced significant links with mathematics achievement in all waves, except for 2003. At the school level, there was no clear pattern of relationships between the factors and mathematics achievement when student-level factors were considered.

5. Discussion

This study examined student- and school-level factors associated with Malaysian adolescents' mathematics achievement over the last two decades. To help readers understand the results, first, the main results are summarized and followed by interpretation and discussion.

5.1. Summarizing the findings

The results suggested that more than 50% of the variation in mathematics achievement of Malaysian students in all six waves of the TIMSS assessment, except for TIMSS 2015 (43.16%), was due to between-school differences, indicating that students' mathematics achievement is highly affected by schools.

Self-concept and intrinsic value had a solid and positive relationship with mathematics achievement in all the TIMSS waves. However, the association for self-concept was stronger. Utility value was not significantly correlated with achievement in the first three assessments but yielded a significant correlation in the last three. Educational aspiration was significantly correlated with achievement in 1999, 2015, and 2019. The language spoken at home was significantly associated with achievement in all the TIMSS assessments. The correlation was negative in the first four assessments; however, it turned positive in the last two assessments. There was a significant correlation between parents' education and achievement in 1999; the significant correlation disappeared in 2003 and 2007; however, the correlation was significant again in the last three cycles. Home educational resources were significantly related to achievement in 2007, 2011, and 2019. Book ownership was significantly correlated with achievement in all years except 2003.

Among the school-level factors, teachers' gender was highly and negatively associated with achievement in 1999, 2011, and 2019. Students whom female teachers taught achieved higher scores than those whom male teachers taught. The teacher-teaching experience was negatively correlated with mathematics achievement only in 2019. Students whom more experienced teachers taught achieved lower scores; however, after controlling for the student-level factors, the relationship between teacher-teaching experience turned positive.

After controlling for the school-level factors, the means of self-concept and intrinsic value were significantly and positively correlated with achievement in 2003, 2007, and 2019; however, the associations were stronger in 2003 and 2007 than in 2019. Similarly, the mean utility value was significantly correlated with achievement in 2003, 2007, and 2019; however, the correlation in 2019 was minimal. The mean of educational aspiration was significantly correlated with achievement only in 2019. The correlation between the mean of home language and mathematics achievement was significant in 1999 and 2003. The correlation was positive in 1999, but it turned negative in 2003. The mean of parents' education was significantly and positively correlated with mathematics achievement in 2003 and 2007. The mean home educational resources positively correlated with mathematics achievement in 2003 and 2007. The mean of book ownership positively correlated with mathematics achievement in 1999 and 2007.

5.2. School effectiveness theory

School effectiveness and multilevel modeling theory were used as a guide to select the factors affecting students' mathematics achievement in this study. School effectiveness determines how various factors correlate with students' cognitive and affective performance[78]. From the view of the last five decades, schools make no difference, which was the conclusion of the Coleman et al.[79] and Jencks et al.[80] studies. There is a common agreement that schools make a difference in students' academic achievement, and educational policies aim to improve all schools in general and the more ineffective schools in particular[81]. This study provides evidence indicating that schools make students' academic achievement different.

5.3. Expectancy value theory

The findings showed that the relationship between self-concept and intrinsic value with achievement was powerful across the TIMSS assessments. The relationships between motivation and academic achievement have been extensively investigated using the expectancy-value theory (EVT) of motivation[82][83]. EVT indicates that students' expectations of success and value in academic tasks influence achievement choices, performance, effort, and persistence[84]. Utility value is one of the EVT components[83]. Beliefs in learning mathematics are linked with more significant effort, higher self-efficacy, and engagement in mathematical learning[85] and, finally, higher mathematics achievement. Having found a solid link between self-concept, intrinsic value, and utility value with students' mathematics achievement in this study provides support to the EVT and confirms prior findings (e.g., [43][50][51][30][44][52]). This indicates that the weight of motivational factors on students' achievement is higher than that of students' family background factors. This result supports Chepete's[32] findings, who reported that attitudinal factors are more effective on the variation in mathematics achievement than family background factors. This finding has important policy implications because these factors, to some extent, are under the school's control. Through formal and informal instructional activities, schools can form, develop, and reinforce students' motivational beliefs to enhance their academic achievement.

The findings showed that the trend of the relationships between the utility value and students' performance was insignificant in the first three studies. However, this relationship is significant in the following three cycles. This finding can confirm the hypothesis that the role of mathematics and related fields, such as STEM, in the technological knowledge and entrepreneurship of graduates of educational systems is changing rapidly in the world, and the utility value of mathematical knowledge is increasing. The evolving significance of mathematics in educational outcomes reflects a broader transformation within educational systems that align more closely with the demands of the modern workforce. This recognition of the utility value of mathematical knowledge indicates not only a shift in student attitudes but also an urgent necessity for curricula that bridge theoretical understanding with practical application. As the world continues to advance technologically, the imperative for robust mathematical proficiency in fostering technological knowledge and entrepreneurship among graduates will undoubtedly intensify.

Home language, among the other family backgrounds, was the most influential factor. Non-Bahasa speaking background students outperformed their Bahasa speaking background peers. This result is inconsistent with recent findings nationally and internationally[62][63][3][64]. A possible explanation for this inconsistency might be related to the school's location. Usually, wealthier students live in urban areas. They are more advantaged concerning the quality of education (e.g., experienced teachers, more instructional resources, social combination) and family background (e.g., parents' education, home educational resources). Mathematics is the most challenging subject among the other school subjects[86]. Generally, students need support doing their assignments and homework, particularly in mathematics. Advantaged students in urban areas have parental support in doing assignments and homework. Research findings suggest that homework is an influential factor that improves the academic achievement of students who can work independently and those who have sufficient parental support to complete home learning assignments[87][88][89]. Moreover, this outcome may also be partially attributed to cultural differences. As mentioned earlier, the Malaysian population consists of three distinct ethnic groups: Malay, Chinese, and Indian. Chinese students, whether they reside in mainland China, Singapore, Taiwan, or Hong Kong, strive to please their parents and bring honor to their families. Consequently, they exert more effort to meet their parents′ expectations. The TIMSS results consistently reveal that the five East Asian countries, namely Singapore, Hong Kong, Taiwan, South Korea, and Japan, which share a common culture to a large extent, achieved the highest scores in mathematics and science at both the fourth and eighth-grade levels among all participating nations. However, it is important to note that the self-perception of learning these subjects, as well as the intrinsic and practical values associated with them, is not particularly high in these countries. In fact, it is even lower than in many countries where students performed poorly. In conclusion, the finding that home language significantly influences academic performance represents a complex interplay of socio-economic advantages and cultural values. Understanding this relationship is vital to addressing educational disparities and enhancing learning outcomes for all students, especially those from diverse linguistic backgrounds. By recognizing the contextual factors at play, educators and policymakers can work towards creating more equitable learning environments that foster academic success for every student, regardless of their home language.

The most likely explanation for the decline in the achievement of Malaysian eighth-graders over time could be attributed to the change in the language of instruction for mathematics from Bahasa Malaysia to English in 2003. That is, the Malaysian eighth-graders who participated in TIMSS 2007, having studied mathematics (and science as well) in Bahasa Malaysia during their 6 years of primary education, suddenly had to switch to studying both subjects in English[5]. Even though the TIMSS test was conducted in Bahasa Malaysia, there are reasons for the decline. Firstly, students' inability to master the content taught in the English language, and secondly, due to the teachers' insufficient mastery of the English language to explain the mathematics content to the students. Although English is the second language in Malaysia, less educated parents, especially in rural areas, could not support their children in their assignments. Finally, after much debate, the government decided in July 2009 to revert from English to Bahasa Malaysia.

6. Implications

A comprehensive analysis of TIMSS assessments indicates that 43.16% to 73.00% of the variance in mathematical achievement arises from differences among schools. This suggests that equitable resource distribution is vital, as disparities can hinder student performance and perpetuate inequalities. Prioritizing resource allocation is essential for enabling all students to thrive academically. Another crucial finding highlights a strong positive correlation between self-concept, intrinsic value, and mathematics achievement, with self-concept being particularly influential. This emphasizes the need to enhance students' self-esteem and engagement in mathematics, suggesting that educational policies should include mentoring programs to bolster confidence in their mathematical abilities. The significance of educational aspirations is evident in assessments from 1999, 2015, and 2019, indicating that high goals can lead to greater achievement. Schools should implement programs to promote goal-setting and raise awareness of educational pathways, as increased aspirations correlate with improved performance. The evolving correlation between home language and mathematics achievement suggests a shifting role of the home environment in education. This emphasizes the need to consider linguistic diversity in educational strategies, promoting inclusive pedagogical approaches that cater to various language backgrounds. Finally, findings related to teacher gender and experience reveal complex dynamics affecting student performance. The observation that students with female teachers often perform better highlights the importance of gender parity in staffing. Additionally, the changing correlation between teacher experience and student achievement underscores the need to consider contextual factors when evaluating teacher effectiveness.

7. Conclusion

The decline in mathematics performance among Malaysian eighth-grade students has been a consistent trend in successive TIMSS assessments. This research aimed to explore the factors at both the student and school levels that contribute to these differences in mathematics achievement. Multiple multilevel models were utilized to analyze the relationship between mathematics achievement and various factors, using TIMSS data from 1999 to 2019. The analysis revealed several significant findings, ultimately leading to the conclusion that students′ attitudinal factors (such as self-concept, intrinsic value, utility value, and educational aspiration) and their socioeconomic backgrounds, along with compositional and contextual factors at the school level, play a crucial role in explaining the variations in mathematics achievement.

8. Limitations

Several limitations of the study should be borne in mind when interpreting the results. Firstly, the correlational nature of the data underscores a critical caveat; findings derived from correlational analysis cannot substantiate causal relationships. This limitation necessitates caution in drawing definitive conclusions about cause-and-effect dynamics between variables. Secondly, reliance on self-reported data from students, teachers, and principals raises concerns about the accuracy and objectivity of the information collected. While the mathematics achievement scores are grounded in standardized assessments, the subjective nature of self-reporting may introduce biases, potentially skewing the results. Additionally, it is important to note that TIMSS scores do not impact students' grades or play a role in critical academic milestones such as promotion and graduation. As a consequence, some students may not have exerted their utmost effort in completing the test, leading to questions regarding the representativeness of the performance data. Lastly, the analytical models employed in this study were confined to the student and school levels, omitting an exploration of variances in achievement across different classrooms within the same educational institution. This limitation restricts the comprehensiveness of the analysis and may overlook significant contextual factors influencing student performance.

Ethics Statement

This study analyzed publicly available, de-identified secondary data from the Trends in International Mathematics and Science Study (TIMSS) for Malaysia across six waves (1999, 2003, 2007, 2011, 2015, and 2019). The original data collection procedures, including ethical review and informed consent, were conducted by the International Association for the Evaluation of Educational Achievement (IEA) and the Malaysian National Center, in compliance with international ethical standards and national regulations. As this work involves secondary analysis of anonymized data, no additional ethical approval was required under institutional guidelines.

Data Availability Statement

The datasets supporting this study are publicly available through the TIMSS & PIRLS International Study Center at Boston College. Access procedures, including registration and compliance with IEA terms of use, apply. Data can be retrieved from https://timssandpirls.bc.edu/timss-landing.html

Author Contributions

Conceptualization: E.M. and P-Y.L.; Methodology: E.M. and P-Y.L.; Software: E.M.; Validation: E.M. and P-Y.L.; Formal Analysis: E.M.; Investigation: E.M. and P.A.; Resources: E.M. and P-Y.L.; Data Curation: E.M.; Writing—Original Draft: E.M.; Writing—Review & Editing: P-Y.L. and P.A.; Visualization: E.M.; Supervision: P-Y.L.; Project Administration: P-Y.L.

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